TABLE 2

Table 2: Data Networks

	Description	Target Markets	Geographic Coverage	Leo One Internal Research: Cost of Subscriber Equip.	Leo One Internal Research: Cost of Service	MTA-EMCI Study: Cost of Subscriber Equip.	MTA-EMCI Study: Cost of Service	Economic Analysis: Relative Cost Measure
Little LEOs								
Leo One USA	48 satellite LEO constellation designed t deliver store-and-forward data (shor messages) on a near real-time basi	Tracking, dispatch, monitoring messaging (see application list	Worldwide with limited buildin penetration and some blockage i urban area	$100-50 dependin o functionalit	$1 - $45 per mont depending upo the application			l
Orbcomm	LEO constellation designed to delive store-and-forward data (short messages	Tracking, dispatch, monitoring messagin	Global	$500	$1 - 50 per mont depending on th applicatio	$300	$30 per month	L
Starsys	Little leo constellation 80% owned by G Americom. Utilizes CDMA technology	Transportation services, monitoring tracking, messaging	Global	approx. $500	approx. $1 - $5 per mont depending upo applicatio			l
VITA	Not-for-profit organization with a licens to launch 1 satellite in low earth orbi	Messaging and file transfer to remot areas	Global	$500	unknown			l
Big LEOs								
ICO	10 satellite TDMA MEO satellite system System linked to the public switche network through 3rd parties	Voice communications with low dat rate capabilities	Global.	$1,000 1,50	$1 - 2 per minute			h
Globalstar	48 leo satellite system - eight planes Uses CMDA for mobile links. Will b capable of data rates of 1.2, 2.4, 4.8 an 9.6 kbps. Bent pipe returning traffic to in country public switched gateways	Voice communications with low dat rate capabilities	Global.	$750	$0.35 - $0.50 pe minut			m
Iridium	GSM based architecture 66 satellite le system. TDMA and FDMA mixture o uplink and downlink	Voice communications with low dat rate capabilities	Global.	$3,000	$3.00 per minute			h
Odyssey	12 satellite system in medium earth orbit Founded by TRW and Teleglobe Canada	Offers voice, data, fax, paging messaging, and position location. Dat transmitted at 9.6 kbps	Global.	$1,000 $2,00	< $1.00 per minute			h
Geo-Synchronous								
Inmarsat	Geostationary satellite system owned b international organization of 79 countries Original focus was on the maritim community	Two-way direct dial telephone facsimile, telex, e-mail, and dat communications. Data rates up to 6 kbps	Global	$5,000 $20,00				H
AMSC (Skycell)	Geosyncronous satellite providin telephone, location, voice dispatch an data transmission capabilities	Dispatch services for trucks emergency vehicles, and othe transportation fleets	Continental US, Alaska, Hawaii Puerto Rico and Virgin Islands	$2,500 $5,00 dependin on th capabilitie of the unit	$69/month for on zone, $99 pe month for tw zones -- include 100 free minutes Additional minute are $1.65	$1,800	$65 per month	H
Omnitracs/Boatracs (Qualcomm)	Geostationary satellite system owned b Qualcom	Offers mobile data services to th trucking and maritime industrie		$3,500 $3,70	$50 per mont includes messages per day	$3,000	$80 per mont averag	H
Terrestrial Voice & Data								
Highwaymaster	System that relies on roaming betwee cellular system throughout the countr	Trucking industry. Company ha recently annouced joint venture wit Motorola to offer automobil information and monitoring service	Coverage over most of the country.	$2,245	$41 per month $0.50 per minut (truck service	$2,000	$0.48 per minut data; $0.53 pe minute voic	H
VHF Radio Systems/WaterComm	VHF Radio systems are used fo communications by marine traffic	Primarily voice. Not a private or secur communication link	Waterways and coastlines.	$200 $1,10	no charge			L
Cellular	Analog cellular systems in major and rura markets throughout the countr	Designed for voice communications o a switched basis. Data is available o a per minute basis	Most of the United States	$500 modem	$0.20 - $1.00 pe minute + roamin (ave. user $12/mo.	$500	$12 per mont average dat usag	L

Table 2: Data Networks

				Leo One Internal Research		MTA-EMCI Study		Economic Analysis
	Description	Target Markets	Geographic Coverage	Cost of Subscriber Equip.	Cost of Service	Cost of Subscriber Equip.	Cost of Service	Relative Cost Measure
Broadband PCS	Digital networks being built in majo markets based on a cellular typ architecture	Designed primarily for voice, but dat will also be available. A "paging" typ service will be offered in firs generation handsets	Very limited.	$200+	$0.15 - $0.30 pe minute. Roamin unavailable	$200 - 600	$12 per mont (est.) average dat usag	L
Analog SMR	Trunked radio networks built primarily fo voice communications	Trucking, dispatch	Major markets.	$395	$20 - $30 pe mont	$500-1000 $300-500 fo mode	$7.50 per mont (est.) attributed t dat	L
GeoTek Communications	Spread spectrum system using SM frequencie	Dispatch/scheduling, automate vehicle location, messaging, credi card transaction	Eventually in 36 metropolitan areas			$800 - 1200	$10 - $20 pe mont	M
NexTel	Integrated digital voice and data networ built with frequency reuse	Trucking, dispatch, users that nee integrated voice/data, cellula replacemen	Some major markets.	$600-700	$60 per month.	$800-1200	$65 per mont ($13/mo. for data	M
Terestrial Data								
Ram Mobile Data	Network owned by BellSouth designed t deliver packet data over SM frequencies	Point-of-sale applications, messagin to mobile workers, dispatc	Covers 92% of the US urba population. Has plans to offe customers access t complementary networks (cellular satellite, or CDPD)	$500-600 fo Mobite modem	$25 - $135 pe month dependin on usage	$795	$55 - $65 pe month ave	M
Ardis	Network owned by Motorola designed t deliver packet dat	Point-of-sale applications, messagin to mobile workers, dispatc	Same general coverage as Ra Mobile Data	$500-$800	$25-$135 pe month dependin on usage	$800	$70 per mont ave	M
CellNet	Network designed around a cellular typ architecture but limited to dat	Current focus is on meter reading, bu has plans for monitoring of vendin machines, residential security, etc	Networks built specifically fo untilities with which they hav contracts	unknown	unknown	n/a	n/a	L
Metricom	Mesh network architecture operating o frequencies in an unlicensed ban	Meter reading and SCAD applications for utilities, messagin and internet access	Primarily covers selected academi and corporate "campuses". Som metropolitan rollouts beginning	$150-300	$15-25 per mont for messaging an internet acces	$500	$30 per month	L
CDPD	Packet data network overlay for analo cellular systems	Messaging, file transfer, mete reading, SCADA, telemetry, dispatc	Currently in commercial service o test in 110 markets	$800 fo CDP modem	$0.036 to $0.12 pe kilobyte dependin upon the servic pla	$800	$0.3-$0.12 pe kilobyte - Average Credit car verification $11/mo. Messaging $55/mo.; Alar polling - $14/mo	M
Cellemetry	Technology developed by BellSouth t transmit small data messages using th control channel of analog cellular system	Vending machine monitoring, mete reading, security system monitorin	Currently being tested in severa markets. Very limited commercia availability	$100	$5 per month fo alarm monitoring $10 for shor messagin	n/a	n/a	I
Pinpoint Communications	Network providing high speed dat through patented ARRAY technolog	Fleet management, tracking messaging, and file transfer	First phase includes 2 metropolitan area			$300	$15 per month	I
Nexus Telecommunications	Digital spread spectrum system operatin in the ISM ban	Vending machines, remote securit monitoring, meter readin	Currently being tested.			n/a	n/a	I
Narrowband PCS	Skytel has the only two-way system, wit limited return path capabilities. Others wi be built (Mobilecomm, PageNet, etc.	Messaging, SCADA, Telemetry	Major markets.	$250	$40-60 per month.	$200 - 400	$30 per month (tw way paging	I
AirTouch Teletrac	Data network built in ISM band	Mobile data and vehicle location	6 metropolitan markets			$500	$32 per month	L

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Grants

National Science Foundation. Grant title: "Income Maximizing in Choice and Rate Effects," 1988 - 1991.

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Professional Activities

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APPENDIX B

APPENDIX B

COMPARATIVE ANALYSIS OF SYSTEM PROPOSALS

The FCC has proposed licensing additional NVNG MSS systems in the spectrum allocated at WARC-92. The following analysis evaluates the viability of each of the Notices' proposed license allocations: Little LEO System 1, System 2 and System 3. In summary this analysis indicates that the proposed approach does not make efficient use of the available spectrum and will not support economically viable competitors. As a result of this analysis Leo One USA recommends an alternative proposal that maximizes the efficient use of the spectrum and supports two economically viable systems: System A and System B. Support for this conclusion is presented below and in the accompanying economic analysis contained in Appendix A. Finally, an analysis is made of the increase to the Orbcomm system capacity if its pending second round amendment requesting additional spectrum is granted, rather than introducing additional competitive systems.

Because Orbcomm represents the largest licensee, Orbcomm's 36 satellite system is used as the relative standard for comparing the capacities of the three spectrum allocations proposed by the Commission, the alternate two allocations proposed by Leo One USA, and Orbcomm's proposed modified allocation. The following sections calculate what the capacity of Orbcomm's 36 satellite system would be if it were constrained to operate in each of the proposed allocations.

Orbcomm's authorized 36 satellite system consists of four planes of eight satellites each inclined at 45° to the equator and two planes of two satellites each inclined at 70°. The 45° inclined planes are separated by 135°, the satellites in each plane by 45°, and the inter-plane phasing angle is 0°. The 70° inclined planes are separated by 180°, the satellites in each plane by 90°, and the inter-plane phasing angle is 0°.

Assuming a 10° elevation mask, an average of 1.4 satellites are visible to a subscriber at 36° latitude. Each satellite has a subscriber downlink capacity of 9.6 kbps. Thus Orbcomm's average subscriber downlink capacity is 1.4 x 9.6 kbps x 86,400 sec/day = 1,160 Mbits per day.

To achieve this capacity, Orbcomm uses 320 kHz of spectrum in the 137 - 138 MHz downlink band, 270 kHz for subscriber links and 50 kHz for gateway links. Orbcomm also has access, on a shared basis, to 995 kHz of spectrum in the 148 - 149.9 MHz band, 50 kHz of which is used for gateway uplinks and 945 kHz for subscriber uplinks. Since Orbcomm had the opportunity to engineer its spectrum requirements, it is assumed that Orbcomm's system is balanced, i.e., that the 945 kHz of shared 149 MHz subscriber uplink spectrum supports the same 1,160 Mbits per day.

Orbcomm uses 15.6% (50 kHz out of 320 kHz) of its available downlink spectrum for gateway operation, the same ratio is assumed for the proposed allocations. Orbcomm's uplink and downlink gateway spectrum is balanced, 50 kHz in each direction, the same balance is assumed for the proposed new allocations.

For purposes of comparison, Starsys' authorized 24 satellite system consists of six planes of four satellites each inclined at 53° to the equator. The planes are separated by 60°, the satellites in each plane by 90°, and the inter-plane phasing angle is 0°.

Assuming a 10° elevation mask, an average of 1.22 satellites are visible to a subscriber at 36° latitude. Each satellite has a subscriber downlink capacity of 2.4 kbps. Thus, Starsys' average subscriber downlink capacity is 1.22 x 2.4 kbps x 86,400 sec/day = 253 Mbits per day, approximately 22% of Orbcomm's capacity.

Table 1 summarizes the results. Table 2 describes the proposed frequency pairing for System A and System B. The conclusion is that System 1 is economically unviable, System 2 is non-optimal, and System 3 is both economically unviable and competitively handicapped by being prohibited in its allocation from serving maritime and aeronautical markets. Systems A and B make efficient use of the spectrum, create two economically viable licensees and are able to serve land, maritime, and aeronautical markets, effectively leading to a competitive marketplace.

Table 1. Capacity of Orbcomm System if Operated in NPRM System 1, 2, or 3, or if Operated in New System A, or B or if Orbcomm Second Round Amendment is Granted.

	Downlink as % of Orbcomm	Uplink as % of Orbcomm	Balanced as % of Orbcomm
NPRM System-1	5.7%	9.1%	5.7%
NPRM System-2	92%	84%	84%
NPRM System-3	85%	16%	16%
System A	90%	98%	90%
System B	92%	98%	92%
Modified Orbcomm	128%	116%	116%

Table 2. Frequency Pairing for Proposed System A and System B

	System A	System B	Sharing
Uplink	148.905 - 149.810 MHz 149.810 - 149.855 MHz 150.000 - 150.050 MHz	148.905 - 149.810 MHz 149.855 - 149.900 MHz 149.950 - 150.000 MHz	with Orbcomm and terrestrial time-shared with VITA LMSS and shared with RNSS
Downlink	400.150 - 400.505 MHz 400.505 - 400.5517 MHz 400.645 - 401.000 MHz		time shared with DMSP time shared with VITA time shared with DMSP
Downlink		137.025 - 137.175 MHz 137.333 - 137.367 MHz 137.753 - 137.787 MHz 137.825 - 138.000 MHz	time shared with NOAA time shared with NOAA time shared with NOAA time shared with NOAA

NPRM System 1

The Commission proposes that this system use the 149.81 - 149.9 MHz band for uplink and the 400.5050 - 400.5517 MHz band for downlink. All of this spectrum must be time-shared with VITA, which is authorized to operate a one satellite system. At 36° latitude, the VITA satellites will be visible approximately 5% of the time. Downlinks in the 400 MHz band require Doppler guard bands 2.9 times larger then those at 138 MHz. Each Orbcomm downlink channel requires 6.1 kHz of Doppler guard band. At 400 MHz, each downlink channel requires 17.7 kHz of Doppler guard band. Thus 11.6 kHz of additional guard band is required for each downlink channel.

- Downlink [400.5050 - 400.5517 MHz]

Available downlink spectrum	46.7 kHz
-15.6% for gateway operation same ratio as Orbcomm	-7.3 kHz
-23.2 kHz additional Doppler guard bands for two channels one gateway and one subscriber	-23.2 kHz
=Equivalent 138 MHz subscriber downlink spectrum	16.2 kHz
x 1,160 Mbits per day / 270 kHz	70 Mbits/day
-5% cessation of transmission to coordinate with VITA NPRM @ 46	- 4 Mbits/day
Total Downlink Capacity	66 Mbits/day
As a percentage of Orbcomm capacity	5.7 %

- Uplink [149.81 - 149.9 MHz]

Available uplink spectrum	90 kHz
-spectrum for gateway operation balance with downlink	-7.3 kHz
=Effective subscriber spectrum	82.7 kHz
x 1,160 Mbits per day / 945 kHz	102 Mbits/day
-5% cessation of transmission to coordinate with VITA NPRM @ 46	-5 Mbits/day
Total Uplink Capacity	97 Mbits/day
As a percentage of Orbcomm capacity	8.4%

System-1 provides 5.7% of Orbcomm's balanced capacity.

NPRM System 2

The Commission proposes that this system use the 148.905 - 149.81 MHz band for uplinks and a number of segments of the 137 - 138 MHz band for downlinks. The uplink spectrum is shared with Orbcomm. The 137.333 - 137.367 MHz and 137.753 - 137.787 MHz segments are available for 100% duty-cycle utilization after the NOAA satellites become inoperable. Use of the 137.025 - 137.175 MHz and 137.825 - 138 MHz segments must be time-shared with NOAA.

- Downlink [137 - 138 MHz]

Available downlink spectrum	393 kHz
-15.6% for gateway operation same ratio as Orbcomm	-61 kHz
= Equivalent 138 MHz subscriber downlink spectrum	332 kHz
x 1,160 Mbits per day / 270 kHz	1,426 Mbits/day
-25% cessation of transmission to coordinate with NOAA NPRM @ 55 & 70	-357 Mbits/day
Total Downlink Capacity	1,069 Mbits/day
As a percentage of Orbcomm capacity	92%

- Uplink [148.905 - 149.81 MHz]

Available uplink spectrum	905 kHz
-50 kHz for avoiding Orbcomm's gateway	-50 kHz
-gateway operation balance with downlink	-61 kHz
=Effective subscriber spectrum	794 kHz
x 1,160 Mbits per day / 945 kHz	975 Mbits/day
Total Uplink Capacity	975 Mbits/day
As a percentage of Orbcomm capacity	84%

System-2 provides 84% of Orbcomm's balanced capacity.

NPRM System 3

The Commission proposes that this system use the 149.95 - 150.05 MHz band for uplinks, and the 400.150 - 400.505 MHz and 400.645 - 401 MHz band segments for downlinks. Downlinks in the 400 MHz band require Doppler guard bands 2.9 times larger then those at 138 MHz, thus 11.6 kHz of additional guard band is required for each downlink channel. The uplink spectrum is allocated for land-mobile satellite service (LMSS) and thus this system will be precluded from providing service to airplanes and ships. The uplink spectrum is also shared with the Russian radio-navigation satellite service (RNSS). The downlink spectrum must be time-shared with DMSP. Each DMSP satellite is assigned one of the two sub-bands, footprint overlap with a DMSP satellite requires that this system cease transmission in that sub-band.

- Downlink [400.150 - 400.505 MHz & 400.645 - 401 MHz]

Available downlink spectrum	710 kHz
-Gateway spectrum with increased Doppler guard bands	-123 kHz
1 channel in each segment required for DMSP coordination	
-244 kHz additional Doppler guard bands for 20 channels	-244 kHz
10 channels per segment using all available spectrum	
= Equivalent 138 MHz subscriber downlink spectrum	343 kHz
x 1,160 Mbits per day / 270 kHz	1,474 Mbits/day
-33.3% cessation of transmission to coordinate with DMSP	-491 Mbits/day
20% both sub-bands & 26.6% one sub-band	
Total Downlink Capacity	983 Mbits/day
As percentage of Orbcomm capacity	85%

- Uplink [149.95 - 150.05 MHz]

Available uplink spectrum	100 kHz
-Gateway spectrum balance with downlink	-50 kHz
=Effective subscriber spectrum	50 kHz
5 10-kHz channels @ 2.4 kbps each reduced by 36% S-ALOHA efficiency	373 Mbits/day
-50% to account for RNSS sharing	-186 Mbits/day
Total Uplink Capacity	187 Mbits/day
As percentage of Orbcomm capacity	16%

System-3 provides 16% of Orbcomm's balanced capacity. Additionally, this system is severely handicapped by only being able to address Land Mobile Satellite Services whereas Orbcomm can address Land, Maritime, and Aeronautical Mobile Satellite Services.